



Program Update

Reducing Air Pollution from Nonroad Engines

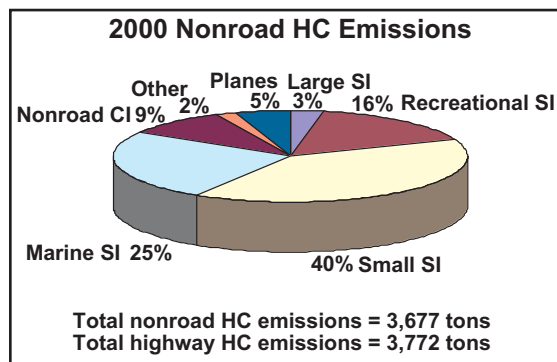
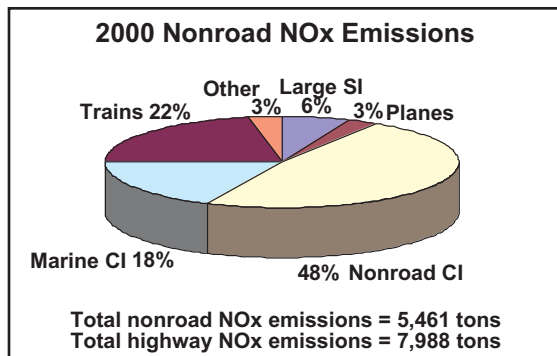
In response to environmental and public health concerns, the U.S. Environmental Protection Agency (EPA) has established emission standards for several nonroad engine categories. These engines operate in a wide variety of applications, including farm and construction equipment, lawn and garden equipment, marine vessels, and locomotives. As a whole, these emission control programs significantly reduce the impact of nonroad engines and equipment on the nation's air quality.

Background

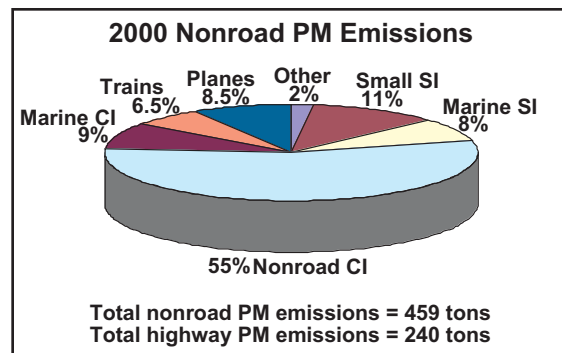
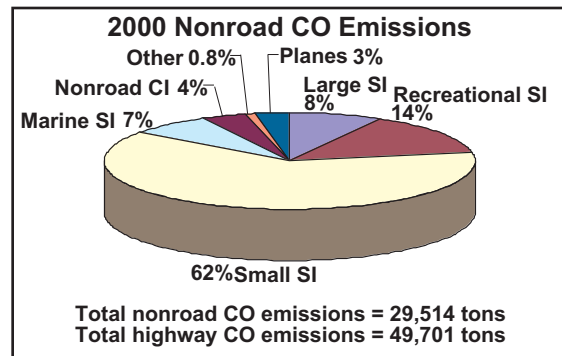
At EPA, we have set increasingly stringent emission standards for highway cars and trucks since the early 1970s. After making much progress in controlling highway emissions, we turned our attention to the wide variety of nonroad engines, which also contribute significantly to air pollution. These programs reduce harmful air pollution and help states meet the National Ambient Air Quality Standards.

“Nonroad” is a term that covers a diverse collection of engines, equipment, vehicles, and vessels. Sometimes referred to as “off-road” or “off-highway,” the nonroad category includes outdoor power equipment, recreational vehicles, farm and construction machinery, lawn and garden equipment, marine vessels, locomotives, aircraft, and many other applications. Until the mid-1990s, very few of these engines faced any kind of emission standards.

The 1990 amendments to the Clean Air Act directed us to study the contribution of nonroad engines to urban air pollution, and regulate them if they contributed to air quality problems. In 1991, we published a report showing that nonroad equipment emitted large amounts of oxides of nitrogen (NO_x), hydrocarbon (HC), carbon monoxide (CO) and particulate matter (PM). In general, we found that nonroad engines had total emissions almost as high as highway engines. In the case of particulate matter, nonroad emissions were significantly higher than highway emissions.¹ The following pie charts show updated emission estimates.



¹ We refer to the combined set of highway and nonroad engines as mobile sources. This does not include stationary engines, which are regulated by separate programs, usually at the state level.



In response, we have initiated regulatory programs for several categories of nonroad engines. The following sections summarize the status of these programs for the various nonroad equipment categories.

Land-Based Diesel Engines

Nonroad diesel engines dominate the large nonroad engine market. They currently contribute about 20 percent of NO_x emissions and 36 percent of PM emissions from mobile sources.²

² Diesel engines may also be referred to as compression-ignition (or CI) engines. These engines typically operate on diesel fuel, but other fuels may be also be used. In contrast, spark-ignition (or SI) engines generally operate on gasoline, natural gas, or liquefied petroleum gas.



Examples of applications falling into this category include agricultural equipment such as tractors, construction equipment such as backhoes, material handling equipment such as heavy forklifts, and utility equipment such as generators and pumps.

Examples of Nonroad Diesel Equipment:

tractors
backhoes
bulldozers
forklifts
generators
pumps

In 1994, we issued the first set of emission standards (“Tier 1”) for all nonroad diesel engines greater than 37 kilowatts (50 horsepower), except those used in locomotives, marine vessels, and underground mining equipment.³ The Tier 1 standards were phased in for different engine sizes between 1996 and 2000, reducing NOx emissions from these engines by 30 percent.

³ The U.S. Mine Safety and Health Administration sets requirements related to emissions from underground mining equipment.

We have since adopted even more stringent emission standards for NOx, HC, and PM from new nonroad diesel engines. This program includes the first set of standards for nonroad diesel engines less than 37 kW (phasing in between 1999 and 2000), including marine propulsion and auxiliary engines in this size range. It also phases in more stringent “Tier 2” emission standards from 2001 to 2006 for all engine sizes and adds yet more stringent “Tier 3” standards for engines between 37 and 560 kW (50 and 750 hp) from 2006 to 2008. These standards will further reduce nonroad diesel engine emissions by 60 percent for NOx and 40 percent for PM from Tier 1 emission levels.

We are currently pursuing new emission standards and measurement methods that focus on controlling NOx and PM emissions from the wide range of in-use operation.

Land-Based Spark-Ignition Engines

We divide land-based spark-ignition engines into three broad categories—small engines typically used for lawn and garden applications, large engines used in industrial applications, and specialty engines used in recreational applications.

Small SI Engines

Small SI engines at or below 19 kW (25 hp) contribute about 20 percent of HC emissions and 23 percent of CO emissions from mobile sources. These engines, which usually run on gasoline, are used primarily in lawn and garden equipment, such as lawnmowers, string trimmers, leaf blowers, chain saws, commercial turf equipment, and lawn and garden tractors.

Examples of Small SI Equipment:

augers
brush cutters
chainsaws
edgers
lawn mowers
lawn tractors
leaf blowers
tillers
trimmers

Under the Phase 1 regulations, new Small SI engines have had to meet emission standards for HC, CO, and NO_x since 1997. These standards apply to all nonroad SI engines at or below 19 kW except those used for marine propulsion, for recreational applications (such as motorcycles or snowmobiles), or for toy boats and airplanes. The Phase 1 standards have resulted in a 32 percent reduction in HC levels.



We recently adopted Phase 2 standards for Small SI engines. For nonhandheld applications (such as lawn and garden tractors and lawnmowers), these standards phase in between 2001 and 2007 and will result in an additional 60 percent reduction in HC and NO_x emissions beyond Phase 1 levels. For handheld applications (such as leaf blowers and chainsaws), these standards phase in between 2002 and 2007 and will result in an additional 70 percent

reduction in HC and NO_x emissions beyond Phase 1 levels.

Large SI Engines

Nonroad SI engines above 19 kW (25 hp), which are usually car and truck engines installed in industrial equipment are used in a wide variety of applications, including forklifts, airport ground-service equipment, generators, compressors, welders, aerial lifts, and ice grooming machines. These engines, which may operate on gasoline, liquefied petroleum gas, or natural gas, contribute about 2 percent of NO_x and HC emissions, and 3 percent of CO emissions from mobile sources. Many of them operate indoors, where high exhaust concentrations often expose workers to dangerous levels of CO emissions.

We will propose emission standards for Large SI engines in 2001. The emission standards already adopted by the California Air Resources Board for these engines, which phase in between 2001 and 2004, serve as the starting point for this effort. Application of basic automotive emission control technologies can reduce CO, NO_x, and HC emissions by about 90 percent.

Examples of Large SI Equipment:

forklifts
airport ground-service equipment
generators
compressors
welders
aerial lifts
ice machines

Recreational SI Engines

We will propose emission standards in 2001 for engines used in nonroad recreational applications, such as

motorcycles, all-terrain vehicles, and snowmobiles. This may also include motorized scooters, mini-bikes, and some mopeds. These engines contribute about 8 percent of HC emissions and 5 percent of CO emissions from mobile sources. This is especially important in areas where their concentrated use can cause problems for local air quality, operators, or bystanders. Emission control technologies appear to be available to substantially reduce emission levels without sacrificing the performance of these engines.

Examples of Recreational SI Vehicles:

motorcycles
all-terrain vehicles
snowmobiles

Marine Engines

Marine vessels vary widely in the sizes and types of engines they use. We have divided marine engines into three broad categories for setting emission standards: (1) gasoline-fueled outboard engines and personal watercraft; (2) sterndrive and inboard gasoline engines; and (3) marine diesel engines. While marine diesel auxiliary engines are included under these marine programs, gasoline-fueled auxiliary engines must meet emission standards that apply to land-based engines.

Outboard and Personal Watercraft Engines

These engines, which have typically used simple two-stroke technology, contribute about 12 percent of HC emissions from mobile sources. Emission standards for outboard and personal watercraft engines call for manufacturers to meet increasingly stringent HC levels over a nine-year phase-

in period starting in 1998. By 2006 all manufacturers will produce engines with 75 percent lower HC emissions. The gradually decreasing emission standard allows manufacturers to determine the best approach to achieving the targeted reductions over time by allowing them to phase in the types of control technologies in the most sensible way, while minimizing the cost impact to the consumer.

Sterndrive and Inboard Gasoline Engines

Sterndrive and inboard gasoline engines typically use four-stroke automotive engines that have been modified for sport boats. Emissions from recreational marine diesel engines account for about 0.5 percent of NO_x emissions and about 0.2 percent of PM emissions from mobile sources. However, because of the nature of their operation, the contribution of these engines to total emissions in and around marinas and harbors is higher. Also, CO emissions from these engines pose an ongoing safety threat to boaters.



Uncontrolled emission levels from these engines are usually considerably lower than from outboard engines, but there is still an opportunity to significantly reduce NO_x, HC, and CO emissions. We are developing emission standards that would require manufacturers to use available emission control technology on their new engines.

Marine Diesel Engines

Marine diesel engines are a diverse nonroad category that includes small auxiliary and propulsion engines, medium-sized propulsion engines on coastal and harbor vessels, and very large propulsion engines on ocean-going vessels. These engines contribute about 7 percent of NO_x emissions and 6 percent of PM emissions from mobile sources, though the contribution is much greater in areas with commercial ports.



At the international level, emissions from marine diesel engines are controlled by Annex VI of the International Convention on the Prevention of Pollution from Ships (commonly known as the MARPOL convention). The NO_x limits, contained in Regulation 13, apply to marine diesel engines rated above 175 hp. The standards target a 30 percent reduction from uncontrolled levels. The standards apply to engines installed on vessels whose construction starts on or after January 1, 2000, even if they will operate only within the U.S. The standards also apply when someone substantially modifies one of these engines on or after January 1, 2000, regardless of the engine's age.

On the national level, we have adopted emission standards that go beyond the MARPOL Annex VI levels for commercial marine diesel engines that will be installed on U.S.-flagged vessels. These standards

apply to new commercial marine diesel engines produced in 2004 or later. For very large engines, these standards begin in 2007. Manufacturers will likely use technologies from highway and land-based nonroad engines to reduce emissions from the similar marine engines. These standards will reduce NO_x emissions by 24 percent and PM emissions by 12 percent.

Recreational marine diesel engines are usually calibrated for greater power output and are used much differently than counterpart commercial engine models. We are considering these and other factors in a current effort to set emission standards for these engines. We expect that manufacturers will use the same kind of emission control technologies they are developing for the commercial engines.

Locomotives

Locomotives contribute about 9 percent of NO_x emissions and 4 percent of PM emissions from mobile sources. These engines are generally larger and last longer than any land-based nonroad diesel engines. New emission standards will reduce NO_x emissions by two-thirds, while HC and PM emissions from these engines will decrease by 50 percent.

Three separate sets of emission standards have been adopted, with applicability of the standards dependent on the date a locomotive is first manufactured. The first set of standards (Tier 0) apply to locomotives and locomotive engines originally manufactured from 1973 through 2001 any time they are manufactured or remanufactured. This is a unique feature of the locomotive program, which is critical because locomotives are generally remanufactured 5 to 10 times during their total service lives of 40 years or more.



The second set of standards (Tier 1) apply to locomotives and locomotive engines originally manufactured from 2002 through 2004. These locomotives and locomotive engines will be required to meet the Tier 1 standards at the time of original manufacture and at each subsequent remanufacture.

The final set of standards (Tier 2) apply to locomotives and locomotive engines originally manufactured in 2005 and later. Tier 2 locomotives and locomotive engines will be required to meet the applicable standards at the time of original manufacture and at each subsequent remanufacture.

Aircraft

Aircraft emissions contribute about 1 percent of NO_x emissions and 6 percent of PM emissions nationwide from mobile sources. Some cities with a lot of airport traffic see a more pronounced impact from these engines. In addition, commercial aircraft emissions are a fast-growing segment in the transportation sector. An EPA report, "Evaluation of Air Pollutant

Emissions from Subsonic Commercial Aircraft," estimates that commercial aircraft will contribute as much as 10 percent of 2010 mobile source NO_x emissions in at least two cities studied (see below). Aircraft emissions also contribute significantly to global climate change and the depletion of the stratospheric ozone layer.

Emission standards for gas turbine engines that power civil aircraft have been in place for about 20 years. These engines are used in virtually all commercial aircraft, including both scheduled and freight airlines. The standards do not apply to military or general aviation aircraft. Controls on engine smoke and prohibitions on fuel venting were instituted in 1974 and have been revised several times since then. Beginning in 1984, gas turbine engines must comply with limits on hydrocarbon emissions per landing and takeoff cycle.



Due to the international nature of the aviation industry, the International Civil Aviation Organization (ICAO) plays an important role in defining uniform emission standards that can be adopted by individual nations. In May 1997, we adopted ICAO's NO_x and CO emission standards for gas turbine engines. In addition we plan to adopt a second round of more stringent ICAO NO_x standards for gas turbine engines for implementation in 2004.

We are also exploring other ways to reduce air pollution from air transportation. Since 1998, EPA and the Federal Aviation Administration have jointly chaired a national stakeholder process to reduce emissions from aircraft, ground service equipment, aircraft auxiliary power units, and other related equipment through a voluntary program. Stakeholders, which include airlines, aircraft engine manufacturers, airports, state and local air pollution control officials, and environmental organizations, are cooperating to accomplish three tasks:

- Assess existing and projected emissions from each type of aviation-related source category at various types of airports.
- Evaluate a wide range of potential control measures, considering the effectiveness of control, cost, timing, enforceability, SIP and conformity implications, and many other issues.
- Develop a framework for reaching consensus on the goals or targets of a voluntary program.

These three tasks and a resulting agreement should be completed in 2001. A successful agreement will be a big step toward establishing a comprehensive national program for reducing aviation-related emissions.

For More Information

You can access additional documents on nonroad engine programs on the Office of Transportation and Air Quality (OTAQ) Web site at:

www.epa.gov/otaq/nonroad.htm

You can also contact the OTAQ library for document information at:

U. S. EPA
OTAQ Library
2000 Traverwood Drive
Ann Arbor, Michigan 48105
(734) 214-4311

Additional fact sheets go into more detail on these nonroad engine control programs:

General:

- *Emission Standards Reference Guide for Heavy-Duty and Nonroad Engines*, October 1997: map format (EPA420-F-97-014); poster (EPA420-H-97-001).
- *Rebuilding Diesel Engines* (EPA420-F-99-045), December 1999.
- *Voluntary Emission Standards for Blue Sky Series Engines* (EPA420-F-99-048), December 1999.

Land-Based Diesel Engines:

- *New Emission Standards for Nonroad Diesel Engines* (EPA420-F-98-034), August 1998.

Land-Based Spark-Ignition Engines:

- *Final Phase 2 Standards for Small Spark-Ignition Handheld Engines* (EPA420-F-00-007), March 2000
- *New Phase 2 Standards for Small Spark-Ignition Nonhandheld Engines* (EPA420-F-99-008), March 1999
- *Small Engine Emission Standards—Answers to Commonly Asked Questions from Dealers and Distributors* (EPA420-F-98-025), September 1998.

- *Be a Grower, Not a Mower* (EPA420-F-96-018), April 1997.

- *Requirements for Railroads Regarding Locomotive Exhaust Emission Standards* (EPA420-F-99036), September 1999.

Marine Engines:

- *Emission Standards for Marine Diesel Engines: Scope of Application* (EPA420-F-00-006), February 2000.
- *Organization of Gasoline and Diesel Marine Engine Emission Standards* (EPA420-F-99-046), December 1999.
- *Responsibilities for Marine Vessel Operators with EPA-Certified Engines* (EPA420-F-99-044), December 1999.
- *Emission Standards for New Commercial Marine Diesel Engines* (EPA420-F-99-043), November 1999.
- *MARPOL 73/78 Annex VI Marine Diesel Engine Requirements* (EPA420-F-99-038), October 1999.
- *Emission Standards for New Gasoline Marine Engines* (EPA420-F-96-012), August 1996.
- *Emission Standards for New Spark-Ignition Marine Engines: Information for the Marine Industry* (EPA420-F-96-013), August 1996.
- *Boating Pollution Prevention Tips* (EPA420-F-96-003), July 1996.
- *Reducing Marine Vessel and Port Emissions in the South Coast* (EPA420-F-96-011), July 1996.
- *Final Emission Standards for Locomotives* (EPA420-F-97-048), December 1997.
- *Federal Preemption of State and Local Control of Locomotives* (EPA420-F-97-050), December 1997.
- *Environmental Benefits of Emission Standards for Locomotives* (EPA420-F-97-049), December 1997.
- *Emission Factors of Locomotives* (EPA420-F-97-051), December 1997.

Aircraft:

- *Aircraft Contrails Factsheet* (EPA430-F-00-005), September 2000.
- *Evaluation of Air Pollutant Emissions from Subsonic Commercial Aircraft* (EPA420-R-99-013), April 1999.
- *Adopted Aircraft Engine Emission Standards* (EPA420-F-97-010), April 1997.
- *Reducing Aircraft and Airport Emissions in the South Coast* (EPA420-F-96-010), July 1996.

Locomotives:

- *Applicability of Locomotive Emission Standards* (EPA420-F-99-037), September 1999.